Centre for Northern Forest Ecosystem Research Technical Report 001

Methods for Sampling Small Mammals and their Habitats in Boreal Mixedwoods

Ontario

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Centre for Northern Forest Ecosystem Research *Technical Report* **001**

Methods for Sampling Small Mammals and their Habitats in Boreal Mixedwoods

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ABSTRACT

The effects of natural disturbance and human activities on small mammals in the boreal region of northern Ontario are not well understood. Techniques for estimating the distribution and abundance of small mammals are readily available, but methods for identification of life history requisites, particularly habitat requirements, are not well established. Herein we present a protocol suitable for the determination of small mammal distribution and abundance, as well as species-specific habitat requirements. The protocol was developed to assess the influence of alternative timber harvest operations on small mammals in boreal mixedwoods as part of the Canadian Forest Service multidisciplinary research program in the Black Sturgeon Forest of northwestern Ontario. As a result, the methodologies are useful for both the elucidation of basic species-habitat associations and to evaluate the effects of natural and human disturbance on habitat, small mammal distribution and abundance, and biological diversity.

RÉSUMÉ

On connaît mal l'incidence des phénomènes naturels et des activités humaines sur les petits mammifères de la région boréale du nord de l'Ontario. Il existe des techniques d'évaluation de la répartition et de l'abondance des petits mammifères, mais on ne dispose pas vraiment de méthodes pour déterminer les exigences du cycle biologique, en particulier de l'habitat. Nous présentons ici un protocole visant à déterminer la répartition et l'abondance des petits mammifères de même que leurs exigences en matière d'habitat selon l'espèce. Ce protocole a été mis au point pour évaluer l'influence des exploitations forestières parallèles sur les petits mammifères de la forêt mixte boréale dans le cadre d'un programme de recherche multidisciplinaire du Service canadien des forêts dans la forêt Black Sturgeon au nord-ouest de l'Ontario. Par la suite, les méthodes serviront à la fois à élucider les associations de base entre habitats et espèces et à évaluer l'incidence des phénomènes naturels et des activités humaines sur l'habitat, la répartition et l'abondance des petits mammifères, et la diversité biologique.

PREFACE

The protocol described in this technical report was developed to assess the influence of alternative timber harvest operations on small mammals in boreal mixedwoods of the Black Sturgeon Forest in northwestern Ontario during 1993-1995 in fulfillment of the requirements for NODA/NFP Project No. 4049 and was the primary methodology used by C. Hutchison (1997) to assess "The Impact of Alternative Harvesting Practices on the Small Mammal Community in an Ontario Boreal Mixedwood Forest" (M.Sc.F. Thesis, Lakehead University). Although a separate protocol has since been developed for small mammal surveys in Ontario (A. Sugar, T. Bellhouse, D. Phoenix, N. Dawson, G. Holborn and M. McLaren. 2003. A Sampling Protocol for Small Mammal Surveys in Ontario. Ontario Ministry of Natural Resources. Wildlife Assessment Program. WAP-2003-03), a standard approach to the measurement of potentially relevant habitat characteristics is not available. Moreover, the habitat sampling protocol presented herein, especially the definitions of vegetation strata, has been adapted for use in studies of moose calving sites (I. D. Welch. 2000. Calving site selection by GPS-collared moose in timber harvested areas of Northwestern Ontario. M.Sc. Thesis, University of Waterloo) and aquatic feeding areas (J. M. Chikoski. 2003. Effects of timber management practices on the use of aquatic feeding areas by moose (Alces alces) in the Great Lakes – St. Lawrence and boreal transition forests of central Ontario. M.Sc. Thesis, Lakehead University), as well as caribou nursery areas (N. Carr. 2007. Site fidelity in caribou calving areas in Wabakimi Provincial Park and Woodland Caribou Signature Site. M.Sc. Thesis, Lakehead University). Thus, we felt it beneficial to make these methods more readily accessible through the CNFER Technical Report Series.

ACKNOWLEDGEMENTS

Funding for this project was provided through the Northern Ontario Development Agreement, Northern Forestry Program. This report was produced in fulfillment of the requirements for NODA/NFP Project No. 4049, "Influence of environmentally considerate silviculture on bird and mammal populations in boreal mixedwoods".

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TABLE OF CONTENTS

ABSTRACT i

RÉSUMÉ i

PREFACE ii

ACKNOWLEDGEMENTS ii

TABLE OF CONTENTS iii

LIST OF TABLES iv

LIST OF FIGURES iv

INTRODUCTION 1

SMALL MAMMAL SAMPLING 2

HABITAT SAMPLING 5

DISCUSSION 8

LITERATURE CITED 8

APPENDICES 11

Appendix A. Coding Form for Live-trapping Data 11

Appendix B. Data Form for Habitat Sampling (ver. May 1995) 12

Part A - 10-m radius circular plot 12

Part B - 20-m perpendicular transects (shrubs / canopy & ground cover) 13

Part C - 20-m perpendicular transects (fallen logs) 14

Part D - 1m square plots 15

LIST OF TABLES

Table 1. Small mammals that may be found at the Black Sturgeon Boreal Mixedwoods Research Site, based on known distributions in Ontario (Banfield 1974, Dobbyn 1994, Kurta 1995) 3

Table 2. Types of information and codes used to record data for small mammals captured at the Black Sturgeon Boreal Mixedwoods Research Site 4

LIST OF FIGURES

Figure 1. Location of the Black Sturgeon Boreal Mixedwood Research Site, 120 km northeast of Thunder Bay, Ontario 2

Figure 2. Location of trapping grid relative to uncut forest and treatment block at the Black Sturgeon Boreal Mixedwood Research Site. A single Sherman or Longworth live trap was placed at each trap station with either a Tomahawk live trap (squares) or a pitfall trap (circles). Habitat surveys were conducted at 9 trap stations (solid symbols) 3

Figure 3. Circular plot (10-m radius) used to measure characteristics of understorey and overstorey trees, snags, stumps, and downed woody debris, and to assign a V-type based on the the Northwestern Ontario Forest Ecosystem Classification (Sims et al. 1989). The two 20-m transects are used to measure cover type, surface characteristics, fallen log structure, and shrub density. The 4 square plots (1 x 1 m) are used to determine stem density of both herbaceous and woody vegetation, as well as soil surface exposure and litter-soil depth (after Noon 1981) 6

INTRODUCTION

Boreal mixedwoods are a major component of Ontario's forest resource base and are a major contributor to the industrial and social economies of northern Ontario. Sustainable development of this forest type is therefore critical to the health of the forest industry and to the existence of the many northern communities that it supports. Because of their complexity and wide distribution, boreal mixedwoods are also a primary source of many non-timber values such as wildlife habitat, aesthetics, recreation, landscape and biological diversity. Societal pressures, particularly opposition to large-scale clearcutting and herbicide use, combined with increased consideration for non-timber values, have led to strong demands for alternative "integrated resource management" plans in support of "landscape" or "ecosystem management".

These broader management objectives are reflected in recent advisory and policy documents such as "Looking Ahead: A Wild Life Strategy For Ontario" (Ontario Wildlife Working Group 1991) and "Diversity: Forests, People, Communities - A Comprehensive Forest Policy Framework for Ontario" (Ontario Forest Policy Panel 1993). There is a general consensus that the Ontario Ministry of Natural Resources (OMNR) should move away from managing "featured species" to managing for conservation of biodiversity (i.e., for all species). In April, 1994, the Ontario Environmental Assessment Board released its decision on the "Class Environmental Assessment by the Ministry of Natural Resources for Timber Management on Crown Lands in Ontario" which directs the OMNR to develop and implement a program to monitor population trends of representative terrestrial vertebrates. The intent of this monitoring program is to evaluate the effects of natural and human disturbance on wildlife populations and to provide the basic information required for development of integrated resource management plans that maintain or enhance biodiversity.

Before a monitoring program can be implemented, or integrated resource management plans can be developed, those species or groups of species that will be monitored or affected by management plans must be identified. Species-specific life history requirements must also be determined and the availability of these requirements must be assessed to identify those at risk. For Ontario, a preliminary list of species potentially vulnerable to disturbance has been drawn up by the OMNR (Wildlife Policy Branch 1993). However, the specific requirements of most of the species listed are unknown and the influence of disturbances such as existing forestry practices and new alternative timber harvesting approaches on habitat, wildlife populations, and biological diversity in Ontario are uncertain.

Many species of small mammals are among those in need of further examination. A survey of published literature indicates that only two studies of small mammal responses to timber harvesting have been conducted in the boreal region of northern Ontario (Martell and Radvanyi 1977, Martell 1983). The effects of natural disturbance and other human activities on small mammals have not been determined in this region. Techniques for estimating distribution and abundance of small mammals are readily available, but methods to identify life history requisites, particularly habitat requirements, are not well established. Successful development of a monitoring program for small mammals and assessment of their needs over extensive areas requires consistent methods of data collection and analysis.

Herein we present a protocol suitable for the determination of small mammal distribution and abundance, as well as species-specific habitat requirements. The protocol was developed to assess the influence of alternative timber harvest operations on small mammals in boreal mixedwoods as part of the Canadian Forest Service multidisciplinary research program in the Black Sturgeon Forest of northwestern Ontario (Scarratt 2001). As a result, the methodologies are not only useful for the elucidation of basic species-habitat associations, but can also be used to evaluate the effects of both natural and human disturbance on habitat, small mammal distribution and abundance, and biological diversity.

SMALL MAMMAL SAMPLING

There is no generally accepted definition of the term "small mammal". It is usually intended to include small rodents (voles and mice) and insectivores (shrews and moles). Bats are generally not included. Arbitrarily, Delany (1974) suggests the term should be used to describe mammals with body weights up to 120 g. This definition may be too restrictive because it would exclude larger species of rodents (e.g., chipmunks and squirrels) and smaller carnivores (e.g., weasels) commonly found in boreal forests. Therefore, we arbitrarily define small mammals to include those species with average adult body weights less than 200 g (excluding bats).

Methods of sampling small mammals are well-established (e.g., Schemnitz 1980, Davis 1982). All of these techniques provide information about species distribution and most attempt to provide at least relative estimates of abundance. To evaluate the causes of population change, however, requires detailed information about productivity and survival of individuals. Because disturbance commonly leads to habitat fragmentation, immigration and emigration rates must also be measured. Habitat fragmentation may modify movement patterns of individuals, thereby influencing longer-term viability of populations and, ultimately, biodiversity. Our protocol is based primarily on a live-trapping approach that allows use of the mark-recapture methods required to investigate these factors.

The Black Sturgeon Boreal Mixedwoods Research site is located 120 km northeast of Thunder Bay (Figure 1). Based on available distribution maps (Banfield 1974, Dobbyn 1994, Kurta 1995), 22 species of small mammals are expected in the area (Table 1). Because of the broad range of body sizes and differential response of species to traps (Getz 1961, Tanaka 1963, Brown 1967, Morris 1968, Weiner and Smith 1972, Boonstra and Rodd 1982, Williams and Braun 1983, Slade et al. 1993), different sizes and types of traps are required to sample the widest variety of potential species. Traps used at the Black Sturgeon site include Sherman (7.6 x 7.6 x 25.4 cm) and Longworth (6.5 x 8.5 x 14.0 cm) live traps, Tomahawk live traps (15.2 x 15.2 x 48.3 cm), and pitfall traps (Boonstra and Krebs 1978). These traps are suitable for all of the small mammal species expected at

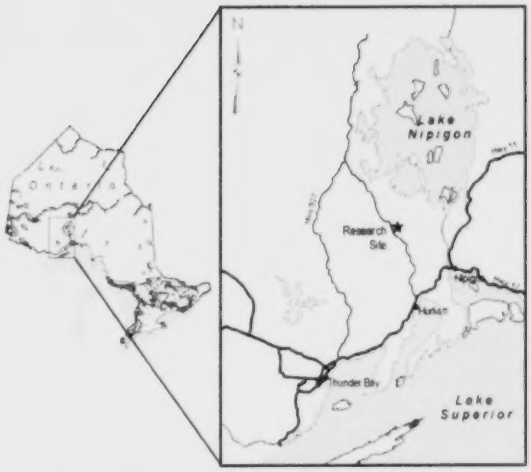

Figure 1. Location of the Black Sturgeon Boreal Mixedwood Research Site, 120 km northeast of Thunder Bay, Ontario.

the site, and may occasionally capture medium sized mammals such as snowshoe hares (*Lepus americanus*), muskrats (*Ondatra zibethicus*), marten (*Martes americana*), mink (*Mustela vison*), and striped skunks (*Mephitis mephitis*).
Trapping grids consist of 5 rows of 9 trap stations spaced 25 m apart (Figure 2), giving an effective trapping area (Kirkland 1977) of about 2.8 ha. Grid dimensions were set primarily by the layout of the 10 ha harvest blocks applied by the Canadian Forest Service at the Black Sturgeon site. Six harvesting methods are under investigation, and all but one of the treatments is replicated three times. Three uncut blocks have also been demarcated. Taken together, these blocks form a graded series of timber volume removal intensities, from no removal in uncut blocks to 100% removal in clearcut treatments. Square treatment blocks are separated by a 100 m buffer zone of uncut forest. Because we wanted to determine the role of "corridors" (i.e., buffer zones) and harvest methods on small mammal populations, particularly immigration and emigration, the centre row of each trapping grid is aligned with the edge of each treatment block. Thus, 2 rows of each grid are in uncut forest and 2 rows are on the treatment block, providing a split plot experimental design.

On each grid, a single Sherman or Longworth live trap is placed within 1 m of each trap station (Figure 2). Whenever possible, traps are placed on the ground in freshly used runways or next to fallen

Table 1. Small mammals that may be found at the Black Sturgeon Boreal Mixedwoods Research Site, based on known distributions in Ontario (Banfield 1974, Dobbyn 1994, Kurta 1995).

Order	Scientific Name	Common Names
INSECTIVORA	*Sorex cinerus*	Masked shrew, Dusky shrew, Common shrew
(Insectivores)	*Sorex palustris*	American water shrew
	Sorex fumeus	Smoky shrew
	Sorex arcticus	Arctic shrew, Black-backed shrew
	Sorex hoyi	Pygmy shrew
	Blarina brevicauda	Short-tailed shrew
	Condylura cristata	Star-nosed mole
RODENTIA	*Tamias striatus*	Eastern chipmunk
(Rodents)	*Tamias minimus*	Least chipmunk
	Tamiasciurus hudsonicus	Red squirrel
	Glaucomys sabrinus	Northern flying squirrel
	Peromyscus maniculatus	Deer mouse
	Clethrionomys gapperi	Southern red-backed vole, Gapper's red-backed vole
	Synaptomys cooperi	Southern bog lemming
	Phenacomys intermedius	Heather vole, Heath vole
	Microtus pennsylvanicus	Meadow vole
	Microtus chrotorrhinus	Rock vole, Yellow-nosed vole
	Zapus hudsonius	Meadow jumping mouse
	Napaeozapus insignis	Woodland jumping mouse
CARNIVORA	*Mustela erminea*	Ermine
(Carnivores)	*Mustela frenata*	Long-tailed weasel
	Mustela nivalis	Least weasel

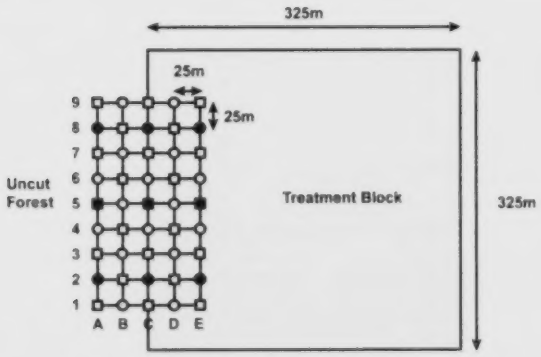

Figure 2. Location of trapping grid relative to uncut forest and treatment block at the Black Sturgeon Boreal Mixedwood Research Site. A single Sherman or Longworth live trap was placed at each trap station with either a Tomahawk live trap (squares) or a pitfall trap (circles). Habitat surveys were conducted at 9 trap stations (solid symbols).

logs or stumps. Small mammals perish rapidly in metal traps, so care must be taken to ensure traps are covered with boards, especially on hot days. Each trap is supplied with cotton bedding and baited with a mixture of whole oats and sunflower seeds. These traps remain at the trapping station throughout the season and are locked open when not in use.

Pitfall traps and Tomahawk live traps are located within 1 m of alternating trap stations on each of the 5 rows, giving an inter-trap distance of 50 m (Figure 2). Tomahawk traps are moved to their trapping location on the first pre-baiting day and moved away from the station after the last trap checking day. While in place, traps are covered with vegetation, and a mixture of whole oats and sunflower seeds is again used for bait. Pitfall traps are set into the ground with the top of the trap level

with the surface. To prevent excessive amounts of rain and debris from entering, pitfall traps are covered with a board which is raised slightly above ground level with small rocks or branches. Pitfall traps are filled with sufficient ethylene glycol to ensure a humane death to any organisms captured and to preserve specimens for later identification and analysis.

Each grid is live-trapped at monthly intervals from June to September. Live traps are pre-baited for 3 consecutive days then set for the following 3 nights. A fourth trapping night is conducted if the recapture rate on the third day is less than 60%. Live traps are set in the early evening, checked each morning within 4 hours following sunrise, and locked open for the remainder of the day. Pitfall traps remain open throughout the season and are checked at bi-weekly intervals to remove captured animals.

Live-trapped animals are transferred to a plastic bag placed over the end of a trap, or into a high-sided container for further handling. Bog lemmings, mice, voles and chipmunks are tagged in both ears with serially numbered #1 Monel self-piercing tags (National Band and Tag Co., Salt Lake Stamp Co.). Squirrels and medium sized mammals that may be caught occasionally are tagged in both ears with serially numbered #3 Monel self-piercing tags. Shrews and moles cannot be effectively ear-tagged and are not marked.

In addition to recording location of capture, ear tag number, species, and sex, the "fate" (i.e., what is done with the animal after it is captured) of each animal is noted (Table 2). All captured animals are weighed to the nearest 0.5 g using a Pesola spring scale (Canadian Forestry Equipment Co.). Testes position (either scrotal or abdominal) is used to describe reproductive condition of males. Reproductive status of females is assessed by noting the condition of the vaginal opening (whether perforate or not perforate), nipples (whether small, medium, or large), and pubic symphysis (whether closed, slightly open, or open). Obviously pregnant females are recorded as such. If females give birth while in a trap, the litter size is noted. All live-trapped animals are released at the point of capture.

Table 2. Types of information and codes used to record data for small mammals captured at the Black Sturgeon Boreal Mixedwoods Research Site. A sample recording form is given in Appendix A.

Information collected	Coding values
1. Treatment unit	1 = uncut "control" 2 = clearcut - feller-buncher, grapple skidder (full-tree extraction) 3 = clearcut - single-grip harvester, grapple skidder (tree-length extraction) 4 = high intensity shelterwood cut - feller-buncher, grapple skidder (full-tree extraction) 5 = high intensity shelterwood cut - single-grip harvester, forwarder (cut-to-length extraction) 6 = high intensity shelterwood cut - manual felling, cable skidder (part-tree extraction)
2. Tag number	(#)
3. Species	1 = *Peromyscus maniculatus* 2 = *Clethrionomys gapperi* (additional numbers as required)
4. Fate	1 = recapture, released 2 = new tag, released (additional numbers as required)
5. Location of capture	1 = row A 2 = row B etc, and station number from 1 to 9
6. Weight	(grams)
7. Sex	1 = male 2 = female
8. Male testes position	1 = scrotal 2 = abdominal
9. Vaginal opening	1 = perforate 2 = not perforate
10. Nipples	1 = small 2 = medium 3 = large
11. Pubic symphysis	1 = closed 2 = slightly open 3 = open
12. Pregnancy	1 = obviously pregnant 2 = not pregnant
13. Litter size	(# of young if born in trap)
14. Week of capture	(week #)

With appropriate coding (Table 2), recorded information may be analyzed using the "Small Mammal Programs for Mark-Recapture Data Analysis" developed by Dr. C.J. Krebs (Department of Zoology, University of British Columbia, Vancouver, B.C., V6T 2A9). Codes used in each information category are flexible and these programs can accommodate a wide variety of experimental designs. This suite of programs provides a much-needed standard for the calculation, analysis and reporting of small mammal population census results. A sample of the form used to record small mammal data at the Black Sturgeon site is given in Appendix A.

HABITAT SAMPLING

Selection of habitat variables for measurement must consider those aspects of the environment that will provide accurate determination of species-specific requirements, as well as predictions of species' response to disturbance. In developing their methods for sampling small mammal habitats, Dueser and Shugart (1978) used four criteria to select variables for measurement: each variable should provide a measure of the structure of the environment which is either known or reasonably suspected to influence the distribution and local abundance of small mammals; each variable should be quickly and precisely measurable with non-destructive sampling procedures; each variable should have intraseasonal variation that is small relative to interseasonal variation; and, each variable should describe the environment in the immediate vicinity of the capture site. Noon (1981) suggests methods of habitat measurement should: yield efficient, precise, and accurate estimates of specific habitat parameters; yield data amenable to statistical analyses, particularly multivariate tests used to generate predictive models; quantify attributes of the environment that are biologically relevant and interpretable for the species; yield data whose predictive capabilities can be tested through simulation models; and, are applicable in different structural habitat types. Due to the hierarchical nature of selection processes (Johnson 1980), habitat variables must be measured at various scales and for vegetation must consider both structure, or physiognomy, and taxa, or floristics: animals may differentiate gross habitat types based on physiognomy, with further refinement of their distribution in a particular habitat based on floristics (Rotenberry 1985). To meet these various objectives, our habitat sampling protocol combines nested quadrats, line transects and point quarter methods, similar to Dueser and Shugart (1978) and Noon (1981).

Habitat surveys are conducted in July (i.e., peak season for vegetation) at 9 of the small mammal trap stations on each treatment block (Figure 2). Three sample points are located in the buffer zone of uncut forest, 3 in the treatment block, and 3 along the interface of the uncut forest and treatment block. At each sampling point, data are collected for 6 strata: overstorey, understorey, shrub level, herb level, forest floor, and litter-soil level. Definitions of these strata have been appropriately modified from those of Dueser and Shugart (1978):

Overstorey - Woody vegetation ≥ 5.0 m in height and ≥ 5 cm diameter at breast height (dbh - approximately 1.3 m above the ground).

Understorey - Woody vegetation > 2.0 m in height and < 5 cm dbh.

Shrub level - Woody vegetation > 0.40 m and ≤ 2.0 m in height, and < 5 cm dbh.

Herb level - Vegetation ≤ 0.40 m in height.

Forest floor - Surface and cover features including mosses and lichens.

Litter/soil - Surface to variable depth ≤ 10.0 cm, including exposed soil, rock, and leaf litter.

Three types of independent sampling units are centred at each point (Figure 3): 4 square plots with 1-m sides, two perpendicular 20-m transects, and a 10-m radius circular plot. The 4 square plots are used to determine stem density of both herbaceous and woody vegetation, as well as soil surface exposure and litter-soil depth. The two 20-m transects are used to measure cover type, surface characteristics, fallen log structure, and shrub density. The large circular plot is used to measure characteristics of understorey and overstorey trees, snags, and downed woody debris. The large plot is also used to assign a "V-type" to the site based on the Northwestern Ontario Forest Ecosystem Classification (Sims et al. 1989).

The two 20-m perpendicular transects and the 10-m radius circular plot are established at a point by placing two 20-m tape measures on top of each other oriented in the cardinal directions (N, S, E, W) to form a "cross". The following habitat features are measured along the two 20-m perpendicular transects:

1. **Shrub density** - Shrub density is estimated by carrying a metre stick along transect lines at breast height (approximately 1.3 m above ground) and counting the number and species of woody stems < 5 cm in diameter, and > 0.40 m but ≤ 2.0 m in height, that are intersected. Counted stems include only the main stem and those stems branching from the main stem.

2. **Canopy cover** - Canopy cover is estimated by sighting through an ocular tube, made from a cardboard cylinder with cross hairs at one end. At 2-m intervals along each transect (i.e., a total of 20 points) the observer sights directly up to the canopy and records all species of shrubs, understorey trees and overstorey trees at the intersection point of the cross hairs.

3. **Ground cover** - Similar to canopy cover, ground cover is estimated by sighting through the ocular tube. At 2-m intervals along each transect (i.e., a total of 20 points) the observer sights directly downward through the tube held at waist height (approximately 1 m above the ground) and records all species of woody and herbaceous vegetation ≤ 0.40 m in height, moss, lichen, leaf litter, decayed wood, exposed soil, and rock at the intersection point of the cross hairs.

4. **Fallen log structure** - The height and number of layers of fallen logs ≥ 1.5 m in length and ≥ 5 cm diameter are recorded at the intersection point of the 2 transects and at 2-m intervals along each transect (i.e., a total of 21 points). The diameter of a fallen log is determined by the maximum diameter attained throughout its length.

The following habitat features are measured within each quarter of the 10-m radius circular plot:

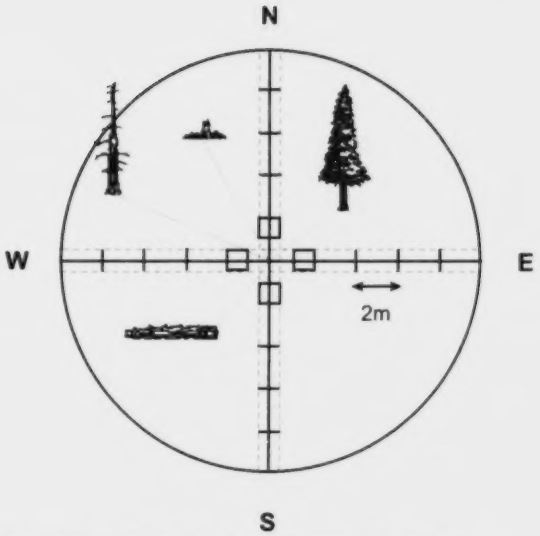

Figure 3. Circular plot (10-m radius) used to measure characteristics of understorey and overstorey trees, snags, stumps, and downed woody debris, and to assign a V-type based on the Northwestern Ontario Forest Ecosystem Classification (Sims et al. 1989). The two 20-m transects are used to measure cover type, surface characteristics, fallen log structure, and shrub density. The 4 square plots (1 x 1 m) are used to determine stem density of both herbaceous and woody vegetation, as well as soil surface exposure and litter-soil depth. (After Noon 1981).

5. **Overstorey tree dispersion** - Species and distance from centre point of the circular plot to the centre point of the nearest overstorey tree where it emerges from the ground, in each quarter.

6. **Overstorey tree size** - Diameter at breast height (dbh - approximately 1.3 m above the ground) of the nearest overstorey tree, in each quarter.

7. **Understorey tree dispersion** - Species and distance from centre point of the circular plot to the centre point of the nearest understorey tree where it emerges from the ground, in each quarter.

8. **Understorey tree size** - Diameter at breast height (dbh - approximately 1.3 m above the ground) of the nearest understorey tree, in each quarter.

9. **Shrub dispersion** - Species and distance from centre point of the circular plot to the centre point of the nearest shrub where it emerges from the ground, in each quarter.

10. **Tree stump density** - Number of tree stumps ≤ 1 m in height and ≥ 5 cm diameter, in each quarter.

11. **Tree stump dispersion** - Distance from centre point of the circular plot to the centre point of the nearest tree stump ≤ 1 m in height and ≥ 5 cm diameter where it emerges from the ground, in each quarter.

12. **Tree stump size** - Diameter of nearest tree stump ≤ 1 m in height and ≥ 5 cm diameter, in each quarter.

13. **Tree stump class** - Decay class (Thomas 1979) of nearest tree stump ≤ 1 m in height and ≥ 5 cm diameter, in each quarter.

14. **Dead tree density** - Number of dead trees > 1m in height, ≥ 5 cm diameter, and angled < 45° from original standing position, in each quarter.

15. **Dead tree dispersion** - Distance from centre point of the circular plot to the centre point of the nearest dead tree > 1 m in height, ≥ 5 cm diameter, and angled < 45° from original standing position, where it emerges from the ground, in each quarter.

16. **Dead tree size** - Diameter of nearest dead tree > 1 m in height, ≥ 5 cm diameter, and angled < 45° from original standing position.

17. **Dead tree class** - Decay class (Thomas 1979) of nearest dead tree > 1 m in height, ≥ 5 cm diameter, and angled < 45° from original standing position.

18. **Fallen log dispersion** - Distance from centre point of the circular plot to the nearest end of a fallen log ≥ 1.5 m in length, ≥ 5 cm diameter, and angled ≥ 45° from original standing position, in each quarter. The diameter of the log is determined by the maximum diameter attained throughout its entire length, whether lying totally within the plot or not.

19. **Fallen log diameter** - Maximum diameter of nearest fallen log ≥ 1.5 m in length, ≥ 5cm diameter, and angled ≥ 45° from original standing position, in each quarter, whether lying totally within the plot or not.

20. **Fallen log length** - Total length of nearest fallen log ≥ 1.5 m in length, ≥ 5 cm diameter, and angled ≥ 45° from original standing position, in each quarter, whether lying totally within the plot or not.

21. **Fallen log class** - Decay class (Thomas 1979) of nearest fallen log ≥ 1.5 m in length, ≥ 5cm diameter, and angled ≥ 45° from original standing position, in each quarter, whether lying totally within the plot or not.

22. The plot is assigned a "**V-type**" using the vegetation key in the Northwestern Ontario Forest Ecosystem Classification (FEC) manual (Sims et al. 1989). Only those species occurring within the 10-m radius circular plot are considered.

The four 1-m square plots are located along the perpendicular transects, 1 m from the centre point (Figure 3). Each square plot is subdivided into 25, 20 x 20 cm squares, and is used to measure the following habitat features:

23. **Woody stem density** - Number of 20 x 20 cm squares in which each live woody-stemmed species, < 0.4 m in height, occurs.

24. **Woody stem cover** - Percent of the 1-m square plot covered by each live woody-stemmed species < 0.4 m in height.

25. **Herbaceous stem density** - Number of 20 x 20 cm squares in which each live herbaceous-stemmed species, < 0.4 m in height, occurs.

26. **Herbaceous stem cover** - Percent of the 1-m square plot covered by each live herbaceous-stemmed species < 0.4 m in height.

27. **Surface component density** - Number of 20 x 20 cm squares in which exposed soil, rock, leaf litter, decayed wood, moss, and lichen occur.

28. **Surface component cover** - Percent of the 1-m square plot covered by exposed soil, rock, leaf litter, decayed wood, moss, and lichen.

In addition to measurements made within quadrats and along transects, two habitat features are measured at distinct sampling points:

29. **Litter depth** - Measured by reading directly from a ruler pushed through litter at 2 points (NE and SW or NW and SE) 1 m from the habitat sampling centre point.

30. **Percent canopy closure** - At a height of 1.5 m immediately above the habitat sampling centre point, a photograph is taken with a hemispherical (i.e., "fish-eye") lens.

Samples of the forms used to record habitat data at the Black Sturgeon site are given in Appendix B.

DISCUSSION

This protocol provides a general approach for the examination of small mammal distribution and abundance, as well as species-specific habitat requirements. Many of the habitat features measured in this protocol may also be useful in understanding the requirements of other wildlife species, such as song birds, reptiles, and amphibians. Elucidation of relationships between wildlife population parameters and habitat characteristics requires further analysis based on multivariate methods. A number of statistical texts dealing with multivariate analysis are available (Morrison 1967, Cooley and Lohnes 1971, Pimentel 1979, Dillon and Goldstein 1984, Harris 1985), as well as examples of their application to the determination of wildlife-habitat relationships (Capen 1981, Shugart 1981, Smith 1981, Brennan et al. 1986, Capen et al. 1986, Digby and Kempton 1987, Ben-Shahar and Skinner 1988, Morrison and Anthony 1989). In many cases, establishment of general relationships will lead to more intensive studies of individual species, requiring more specialized field methods than we have provided in this protocol. At that point, researchers should consult previous studies of the particular species to develop a suitable approach.

Together with other studies at the Black Sturgeon Research site, the small mammal project will provide a valuable case study of the technical aspects, environmental impacts, and silvicultural benefits and constraints of partial cutting in boreal mixedwoods. Although it is not expected to lead to the immediate development of definitive prescriptions for partial cutting in relation to wildlife, the results will help forest managers to judge the operational, economic, and biological feasibility of the approach. More specifically, because of the graded series of harvest treatments applied in the study, our protocol will provide the necessary data forest managers require to gauge the relative influence of harvest level on the forestry/wildlife interface in boreal mixedwoods. The project will provide much needed data on species-habitat associations and provide first approximations of species responses to forest management mediated alterations to habitat structures in boreal mixedwoods.

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APPENDIX A

CODING FORM FOR LIVE-TRAPPING DATA

Plot #	Tag #	Spp #	Fate 1	Loc 1	Wt	Sex	Tstes	Vag	Nipp	Pub sym	Preg	Litter	Fate 2	Loc 2	Week

Date coded: _____ Coded by: _____ Date entered: _____ Entered by: _____

APPENDIX B

DATA FORM FOR HABITAT SAMPLING (ver. May 1995)

Date:_____ **Stand:**_____ **Block:**_____ **Station:**_____

10-m radius circular plot - PART A

Point-quarter variables

Variable	Measurement	Quarter			
		NE	SE	SW	NW
Overstorey tree dispersion	Species				
	Distance from station (m)				
Overstorey tree size	dbh (cm)				
Understorey tree dispersion	Species				
	Distance from station (m)				
Understorey tree size	dbh (cm)				
Shrub dispersion	Species				
	Distance from station (m)				
Tree stump density	Number of stumps				
Tree stump dispersion	Distance from station (m)				
Tree stump size	Diameter (cm)				
Tree stump class					
Dead tree density	Number of dead trees				
Dead tree dispersion	Distance from station (m)				
Dead tree size	dbh (cm)				
Dead tree class					
Fallen log dispersion	Distance from station (m)				
Fallen log diameter	Maximum diameter (cm)				
Fallen log length	Total length (m)				
Fallen log class					

FEC V-type:_____ **Observers:**_____

APPENDIX B

DATA FORM FOR HABITAT SAMPLING (ver. May 1995)

Date:_____ **Stand:**_____ **Block:**_____ **Station:**_____

20-m perpendicular transects - PART B

Shrubs / Canopy & Ground cover

Shrub level species	W/H	# of intersections				
		N	S	E	W	Total
Canopy level species	O/U					
Surface level						
Plants (≤ 0.4m)						
Moss						
Lichen						
Fungi (conks etc.)						
Mushrooms						
Leaf litter						
Decayed wood						
Mineral soil						
Rock						
Fallen logs						

Observers:_____

APPENDIX B

DATA FORM FOR HABITAT SAMPLING (ver. May 1995)

Date:_____ **Stand:**_____ **Block:**_____ **Station:**_____

20-m Perpendicular Transects - PART C

Fallen logs (deadfall)

Transect	Distance from centre (m)	Number of Layers	Height
North	10		
	8		
	6		
	4		
	2		
	0		
South	2		
	4		
	6		
	8		
	10		
West	10		
	8		
	6		
	4		
	2		
East	2		
	4		
	6		
	8		
	10		

Observers:_____

APPENDIX B

DATA FORM FOR HABITAT SAMPLING (ver. May 1995)

Date:_____ **Stand:**_____ **Block:**_____ **Station:**_____

1-m square plot - PART D

Ground cover level (≤ 0.4m)

Plant species / Ground cover	W/H	# of squares					% Cover
		N	S	E	W	Total	
Moss							
Lichen							
Fungi (conks etc.)							
Mushrooms							
Leaf litter							
Decayed wood							
Mineral soil							
Rock							

Litter depth

Depth (mm)				
NE	SE	SW	NW	Average

Canopy closure

Height	Film #	Frame #
1.5 m		

Observers:_____

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